Improved Half-life Measurement of ^{224}Pa and its ^{209}Bi(^{18}O,3*n*)^{224}Pa Production Cross Section

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Two half-lives for ^{224}Pa have been reported previously. However, the error bars of these two measurements, 600±50 ms measured for ^{224}Pa from the ^{232}Th(*p*,9*n*)^{224}Pa reaction[1] and 950±150 ms measured for ^{224}Pa from the ^{205}Tl(^{22}Ne,3*n*)^{224}Pa reaction[2], do not overlap. The former measurement's low value could be due to misinterpretation of the very complex alpha spectrum that was obtained. The disparity could lie in the misidentification of a ^{223}Th (t½=650 ms, a=7.324 MeV) decay peak produced by the ^{232}Th(*p*,*p*9*n*)^{224}Pa reaction.

In our experiment ^{224}Pa was produced via the ^{209}Bi(^{18}O, 3*n*)^{224}Pa reaction which has been previously reported[3], but no production cross section or additional half-life measurement was given. The Lawrence Berkeley National Laboratory 88-Inch Cyclotron provided a 20 particle-nA beam of 111 MeV (laboratory frame) $^{18}O^{5+}$. The target system has been descibed in detail previously[4]. The energy calibration was performed on-line using known alpha decay energies from the following nuclides: ^{211}Bi, ^{214}Ra, ^{211}Po, ^{212}Ac, ^{216}Fr,

The odd-odd nucleus ^{224}Pa is not expected to have a significant beta-decay branch and appears to alpha decay mainly to a single nuclear level in ^{220}Ac with an alpha particle energy of 7.49 MeV[2,5]. Unfortunately, while alpha particles with this energy are identifiable in our alpha-energy spectrum, they are largely obscured by the ^{211}Po transfer product which decays via a 7.45 MeV alpha. Therefore the ^{224}Pa decay was identified by observing its alpha-decay daughters ^{220}Ac (t½=26 ms; α=7.610, 7.680, 7.790, 7.850 MeV)[5] and ^{216}Fr (t½=0.7 ms; α=9.01 MeV)[5]. The ^{224}Pa daughter events were observed with 6 pairs of opposing detectors[6] within 2 μs of each other. By fitting the resultant decay curve with two components, the half-life of ^{224}Pa was determined to be 850±20 ms (see Fig. 1). From these data, we also determined the production cross section to be 0.5±0.1 mb, after taking into account the detector efficiency, capillary transport efficiency, and capillary transport time.

The half-life for ^{224}Pa as determined by this experiment is consistent with, but much more precise than the value of 950±150 ms reported by Borggreen *et al*[2]. Our measured production cross-section is consistent with the value of 0.35 mb calculated with the SPIT code[7].

Footnotes and References

1. P. A. Tove, Arkiv Fysik. **13**, 549 (1958).
2. J. Borggreen, K. Valli, E. K. Hyde. Phys. Rev. C **2**, 1841 (1970).
3. M. Fukuda et al., RIKEN Accel. Prog. Rep. **20**, 14 (1986).
4. D. Lee *et al.*, Phys. Rev. C **25**, 286 (1982).
5. R. B. Firestone, Table of Isotopes, 8th ed. (Wiley-Interscience, New York, 1996).
6. D. C. Hoffman *et al*., Phys. Rev. C **41**, 631 (1990).
7. T. Sikkeland, Ark. Fys. **36**, 539 (1967); J. Alonso, Gmelin Handbook of Inorg. Chem., **7b**, 28 (1974).

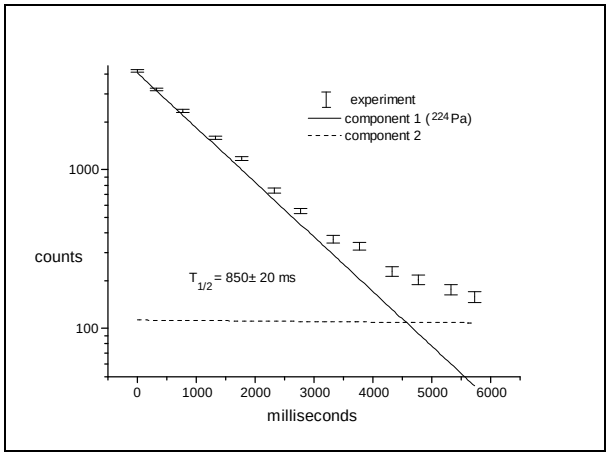

Fig. 1. Decay of ^{224}Pa